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Thesis

UNITS OF MEASUREMENT IN INDUSTRY

by

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UNITS OF MEASUREMENT IN INDUSTRY

INTRODUCTION

Industry is "Labor habitually or systematically employed in beneficial work, especially in manufacture and arts." In other words, modern industry is the production and distribution of goods which are created by human labor, assisted by power and machinery.

The word manufacturing is derived from the Latin and means "made by hand." In modern usage, however, the term usually refers, not to this intrinsic meaning, but to the making of articles by power driven machinery rather than by hand operated tools.

To-day, the standardization of processes and of products has made possible the production of articles in large numbers. In assembling, specialization is carried to the extreme; for example, a worker may be engaged in placing a single piece in a press or in merely watching a machine.

New England industries provide great consuming markets for raw material and industrial equipment. It is distinguished as a region of fine manufactures and its products are turned out in finished form ready for the ultimate consumer. The articles in which New England contributed more than half the United States' total in 1929 include woolen and worsted goods, textile machinery, rubber boots and shoes. In cutlery, edged tools, and plated ware, it contributed about half. Many others were

near the top of the list, averaging from 25% to 50%, such as cotton goods, jewelery, brass and bronze products, tools and several other products.

In this study, the writer has endeavored to select a few of the typical industries in order to determine the actual uses made of the tables of measurement by the persons employed in these industries. The method used is that of observation, report of employer and employee.

DEFINITIONS

FUNDAMENTAL UNITS

1. LENGTH

Inch. An inch is a measure of length equal to 1/12th of a foot or 1/36th of a yard. It is commonly divided into 1/2,1/4,1/8,1/16, etc., or often into 10,100,etc.

Foot. A foot is a measure of length equal to 12 inches.

Yard. A yard is a measure of length equal to 3 feet or 36 inches. It is the standard of English and American lineal measure.

2. AREA

Square Yard. A square yard is a unit of area equivalent to the area of a square the sides of which are 1 yard.

3. VOLUME

Cubic Yard. A cubic yard is a unit of volume equivalent to a cube the edges of which are 1 yard.

4. CAPACITY

Gallon. A gallon is a unit of capacity equivalent to the volume of 231 cubic inches. It is used for the measurement of liquid commodities only.

5. WEIGHT

Pound. A pound is a unit of weight, the avoirdupois pound containing 7,000 grains and divided into 16 ounces, or the troy pound containing 5,760 grains and divided into 12 ounces.

All other units of measure are multiples and submultiples of these fundamental units.

TABLES OF MEASUREMENT

I. LINEAR MEASURE -- 5 Units

Linear Measure for Distances

Table

12 inches	equal	1 foot
3 feet	"	1 yard
$5\frac{1}{2}$ yards	"	1 rod
320 rods	"	1 mile

II. SQUARE MEASURE -- 7 Units

Square measure is used to measure the areas of surfaces.

Table

144 square inches	equal	1 square foot
9 square feet	"	1 square yard
$30\frac{1}{4}$ square yards	"	1 square rod
160 square rods	"	1 acre
640 acres	"	1 square mile

A square is 100 square feet. The acre is the unit in measuring land.

III. CUBIC MEASURE -- 6 Units

Cubic measure is used to measure the volume of solids and the contents or capacity of hollow bodies.

1728 cubic inches	equal	1 cubic foot
27 cubic feet	"	1 cubic yard
$24\frac{3}{4}$ cubic feet	"	1 perch of stone
128 cubic feet	"	1 cord
40 cubic feet	"	1 ton (shpg)

A perch of stone is $16\frac{1}{2}$ ft.long,$1\frac{1}{2}$ ft. wide & 1 ft. high.

A cord of wood is 8' long, 4' wide, and 4' high.

A cubic foot of water contains about $7\frac{1}{2}$ gallons (U.S. Standard), and weighs $62\frac{1}{2}$ pounds. (Avoir.)

IV. LIQUID MEASURE -- 6 Units

Liquid measure is used for measuring liquids and in estimating the capacity of cisterns, tanks, reservoirs, etc.

Table

4	gills	equal	1 pint
2	pints	"	1 quart
4	quarts	"	1 gallon
$31\frac{1}{2}$	gallons	"	1 barrel
2	barrels	"	1 hogshead

1 gallon of water (U.S. Standard) weighs about 8-1/3 pounds and contains 231 cubic inches.

Ordinarily, the barrel contains $31\frac{1}{2}$ gal. In practice, barrels are of various sizes, as are also hogsheads, pipes, butts, etc. The capacity of each is marked upon it.

A barrel for oil or other liquid contains about 50 gallons.

V. APOTHECARIES' FLUID MEASURE -- 5 Units

Apothecaries' fluid measure is used by druggists in prescribing and compounding liquid medicines.

Table

60	minims	equal	1 fluid drachm
8	fluid drachms	"	1 fluid ounce
16	fluid ounces	"	1 pint
8	pints	"	1 gallon

The standard unit of measurement is the wine gallon containing 231 cubic inches.

VI. APOTHECARIES' WEIGHT -- 5 Units

Apothecaries' weight is used by druggists and physicians in compounding and prescribing medicines.

TABLE

20 grains	equal	1 scruple
3 scruples	"	1 dram
8 drams	"	1 ounce
12 ounces	"	1 pound

Drugs and chemicals when used in compounding medicines are weighed by apothecaries' weight. When they are sold at wholesale, avoirdupois weight is used.

VII. DRY MEASURE -- 4 Units

2 pints	equal	1 quart
8 quarts	"	1 peck
4 pecks	"	1 bushel

The Winchester bushel which contains 2150.42 cubic inches is the standard unit of dry measure. It is a hollow cylinder 18½" in diameter and 8" deep.

VIII. TROY WEIGHT -- 5 Units

Troy weight is used in weighing gold, silver, diamonds, and other precious minerals.

3.168	grains	equal	1 karat
24	grains	"	1 pennyweight
20	pennywts	"	1 ounce
12	ounces	"	1 pound

The term karat, in weighing diamonds is a denomination of weight and is equal to 3.168 grains. It is

also used to denote the fineness of gold and means 1/24 part. Gold marked 10k (10 karats) is 10/24 by weight pure gold and 14/24 alloy.

IX. AVOIRDUPOIS MEASURE -- 5 Units

This is the weight in common use in all ordinary trade dealings.

Table

16 ounces	equal	1 pound
100 pounds	"	1 hundredweight
20 hundredwt.	"	1 ton
2,240 pounds	"	1 long ton (or gross ton)

The long ton is used in the U.S. Custom House in determining the duty on merchandise taxed by the ton. Coal and iron are sold wholesale at the mines by the long ton.

X. CIRCULAR OR ANGULAR MEASURE -- 4 Units

Circular or angular measure is used in measuring angles or arcs of circles.

Table

60 seconds	equal	1 minute
60 minutes	"	1 degree
360 degrees	"	1 circle

XI. UNIT MEASURE -- 6 Units

Table

12 units	equal	1 dozen
12 dozen	"	1 gross
12 gross	"	1 great gross
20 units	"	1 score
5 score	"	1 hundred

XII. TIME MEASURE -- 8 Units

Time is the measure of duration.

Table

60 seconds	equal	1 minute
60 minutes	"	1 hour
24 hours	"	1 day
7 days	"	1 week
30 days	"	1 month
52 weeks	"	1 year
12 months	"	1 year
100 years	"	1 century

365 days = common year - 366 days = leap year

XIII. PAPER MEASURE -- 5 Units

Table

24 sheets	equal	1 quire
20 quires	"	1 ream
2 reams	"	1 bundle
5 bundles	"	1 bale

Paper is sold in large quantities by weight; in small quantities, by the quire or ream. In some cases a ream consists of 500 sheets instead of 480. In ordering, it is necessary to give the size of the sheet and weight per ream, as well as the quality.

XIV. LUMBER MEASURE -- 1 Unit

The unit of lumber measure is the board foot. A board foot is a square foot of board 1"(or less) thick. The volume of a board foot of lumber is thus seen to be 144 cubic inches, except when the lumber is less than 1"thick, in which case a board foot is equal to a square foot of surface of the board.

XV. MONEY MEASURE -- 6 Units

Table of United States Money

5 pennies	equal	1 nickel, or five-cent piece
10 pennies	"	1 dime, or ten-cent piece
5 nickels	"	1 quarter, or twenty-five cent piece
10 nickels		1 half dollar, or fifty-cent piece
100 pennies	"	1 dollar
20 nickels	"	1 dollar
10 dimes	"	1 dollar
4 quarters	"	1 dollar
2 half-dollars	"	1 dollar

XVI. ENGLISH MONEY -- 4 Units

English money is the legal currency of Great Britain.

4 farthings	equal	1 penny
12 pence	"	1 shilling
20 shillings	"	1 pound

XVII. FRENCH MONEY -- 4 Units

French money is the legal currency of France.

Table

10 millimes	equal	1 centime
10 centimes	"	1 decime
10 decimes	"	1 franc

XVIII. ELECTRIC MEASURE -- 7 Units

The chief units as generally accepted by electricians are as follows:

Volt The unit of electromotive force. It has been defined by the International Electrical Congress in 1893 and by the United States statute as : that electromotive force which steadily applied to a conductor whose resistance is one ohm will produce a current of one ampere. It is practically equivalent to 10^8 C.G.S. (Centimeter Gram Second) electro magnetic units.

Ohm The practical unit of electrical resistance. The resistance of a circuit in which a potential difference of one volt produces a current of one ampere.

Ampere The practical unit of electrical current. The current produced by one volt acting through a resistance of one ohm.

Watt The unit of electrical energy. The product of ampere and volt, that is, one ampere of current flowing under a pressure of one volt gives one watt of energy.

Coulomb Unit of quantity. Quantity of current which, impelled by one volt, would pass through one ohm in one second.

Farad Unit of capacity. A conductor or condenser which will hold one coulomb under the pressure of one volt.

Joule Unit of work. The work done by one watt in one second.

SUMMARY OF THE UNITS OF MEASUREMENT.

I.	Linear Measure	5	Units
II.	Square Measure	7	"
III.	Cubic Measure	6	"
IV.	Liquid Measure	6	"
V.	Apothecaries' Fluid Measure	5	"
VI.	Apothecaries' Weight	5	"
VII.	Dry Measure	4	"
VIII.	Troy Weight	5	"
IX.	Avoirdupois Measure	5	"
X.	Circular or Angular Measure	4	"
XI.	Unit Measure	6	"
XII.	Time Measure	8	"
XIII.	Paper Measure	5	"
XIV.	Lumber Measure	1	"
XV.	Money Measure	6	"
XVI.	Englisn Money	4	"
XVII.	French Money	4	"
XVIII.	Electric Measure	7	"
TOTAL		93	Units

STUDY OF A SILVERSMITH INDUSTRY.

GORHAM MANUFACTURING CO.

PROVIDENCE, R.I.

The Gorham Manufacturing Company had its beginnings in a little shop on Steeple Street, Providence, in 1831 and remained there until in 1889 it became necessary to secure a new location for the purpose of obtaining more space.

A plot covering several acres and situated on the outskirts of the city was selected. Several large buildings, with plenty of room for expansion, were erected. The growth of the business was largely due to the personal efforts of Mr. Edward Holbrook who advanced through all the branches of the industry from a very minor position to President of the company.

Thirteen acres of land (544,212 square feet) represent the site of the Gorham Company at Elmwood on which the factory is built. The following dimensions will convey an idea of the extent of the works.

Office Building	200' X 60'
Chief Manufacturing Building	303' X 44'
Preparatory Room	205' X 80'
North Wing	224' X 44'
South Wing	256' X 44'
Mechanics' Shop	101½' X 48½'
Silver Foundry	116' X 43'
Bronze Art Foundry	100' X 44'

The total floor space is 241,781 square feet, equivalent to about five and a half acres.

The Preparatory Room is a one story structure of unusual strength. The floor has a foundation of concrete, and the roof and walls are designed to resist great strains owing to the great weight of the heavy machinery. There are twenty four drop stamps mounted on a solid granite foundation seven feet thick. Near them are the cutting, grinding, drawing and embossing presses most of which were built from designs furnished by the company.

A brick building, one story high, is used as a Bronze Statuary and Brass Foundry for the casting of monumental or other work, of any and all kinds, even to the largest size.

"Gorham silver" is a standard throughout the United States and is sold by nearly all of the principal jewelers. The Gorham mark is well known and consists of three small shields in succession, the first shield portraying a lion to signify "sterling", the second containing an anchor, the emblem of the state of Rhode Island, and the third the initial letter "G" (Gorham). Underneath, the word "Sterling" is stamped. This trade-mark on a piece of silver guarantees the sterling standard of purity, that is, 925-1000 fine. Absolute purity, 1000/1000 fine, is impracticable, as it is too soft for durability. American and French silver coins are made of silver of the standard of 900/1000 fine, but the English silver coin is 925/1000 fine and known all over the world as Sterling. In 1868 the Gorham Company adopted the English standard of Sterling, 925/1000 fine and has always kept this standard.

"Gorham plate" which consists of a heavy deposit of pure silver upon a solid body of pure nickel silver has been made by the Gorham Company since 1865 and is noted for its durability.

THE STORY OF THE MANUFACTURE OF A SILVER PLATED FORK.

In making a silver plated fork, there are over thirty distinct operations necessary. German silver, which is a combination of nickel, copper and zinc, is procured in sheet form of varying lengths and thicknesses. This hard, white nickel alloy is used as a basis in making the fork upon which the silver is afterwards deposited. In the Preparatory Room, the metal is thinned or graded according to the correct thickness by placing it between heavy rollers . This thickness varies from 3/16" in parts of the handle to 1/32" at the extremity of the tines. It is then cut into the approximate shape of the fork. This process leaves the metal raw on the edges, therefore, it is sent to a department where the edges are clipped. The shaped blanks are placed in an oven and brought to a red heat in order that they may be readily worked. This process is called annealing.

The fork is then stamped. A steel die is fixed securely in the "bed" and its mate secured in the drop of the machine which does the stamping. The piece of metal, or "blank", is placed upon the bed die. The drop, which varies in weight from 75 pounds to a ton, has a loose strap of belting attached to it. This is carried over a rapidly revolving pulley above the iron uprights, between which the drop slides up and down. The other end of this strap hangs convenient to the operator's reach. As he grasps and tightens it over the pulley, the drop falls with a blow upon the blank, leaving the impression of the die. Where the metal has oozed out between the dies there is usually a small burr left. This is removed by trimming. The

Trade-mark is then stamped on the back of the handle.

From here, the fork is taken to be "bobbed". This is a smoothing off process and is done by using powdered pumice and oil with the object of eliminating scratches, holes, or any other surface imperfections. In all electro-plating operations, the articles to be plated must be perfectly smooth and free from even the slightest scratches, otherwise these will show very plainly after plating. After it has been bobbed, the fork is washed and sent to the plating room where it is to receive a coating of silver.

In the electro-plating room, the fork is suspended by a wire to a metallic rod in a vat made of wood, or other non-conducting substance, in which is a plating solution. Bars of silver are hung at the side of the vat and are connected with the positive pole of the dynamo. The metallic rods are connected with the negative pole. The solution completes the circuit. The length of time the fork remains in the plating solution depends on general conditions, such as atmosphere, heat of room and strength of solution, and the thickness of the deposit required. In general, .001 inch is deposited in one hour and from 6 to 8 amperes are necessary per square foot.

A patent automatic scale, which weighs the silver while depositing, is balanced to the exact weight of silver to be deposited on the fork. When the current is turned on the plating begins. When the proper weight of silver has been deposited, the scale beam rises, springing the switch, breaking the electric current, and stopping the plating immediately. In general, a good deposit of silver takes from 30 to 45 minutes. It is then scratch brushed, polished, and washed. After it has been inspected, the fork is wrapped in tissue and sent to the stock room.

THE BRONZE FOUNDRY.

Bronze metal of high standard of quality is composed of 90% copper and 10% tin and zinc. These materials are placed in a crucible made of graphite and put in a containing furnace. Skilled moulders prepare the moulds from exact models of the piece as it is to be in bronze. The moulds are of sand of an exceptionally fine quality contained in iron frames called "flasks". The molten metal is taken from the furnace and poured into the waiting mould. In the pouring of a large mould such as one which requires from 4000 to 5000 pounds of metal, a sand basin capable of containing all the molten metal required is built upon the large mould. A huge sand plug is affixed in the bottom of this basin. Crucible after crucible is then emptied into the basin until all the metal necessary has been obtained. The plug is then pulled and the molten bronze flows into the mould. When the metal cools, the enveloping sand is knocked away and the cast is cleaned with wire brushes. The cast is then dipped into a strong acid and comes out the color of a new penny. It is now ready for the filers and chasers who go over the surface removing all superfluous projections or "fins", and strengthening the lines of ornamentation.

After the dimensions have been inspected and adjusted in the fitting department, the finished bronze work is ready to be colored. Bronze is capable of taking a great variety of colors, according to the acids which act upon it in different ways. Certain chemicals will develop beautiful greens , while others will produce various shades of brown and black.

"Oxidized bronze", a light tone of brown, is obtained by oxidizing the raw color of the new bronze to a color which it would take if exposed to the atmosphere.

ARCHITECTURAL BRONZE DEPARTMENT

The architectural bronze department uses the template system in measuring the pieces of bronze. " A template is a pattern or a mould used as a guide in mechanical work." In order to obtain a number of pieces of exactly the same dimensions, the draftsman makes a pattern on wood the thickness of the bronze. The dimensions and the places to be holed are marked on these pieces of wood. It is then given to a workman who puts it on a machine where it is scribed on the bronze. Then it is cut out by machine after which the workman may check the measurement or not, but he must take it to the inspector who is responsible for the accuracy of the dimensions.

The template system, therefore, eliminates to a great extent the need of constant measurement by the person on the job.

GORHAM MANUFACTURING CO.

ARTICLES MANUFACTURED.

SILVERWARE DEPARTMENT

Flat ware pieces - Sterling Silver or Gorham plate

Staples - sold in quantities of 12-8-6-1

Tea spoons,
- small
- regular
- medium
- heavy
- extra heavy

Dessert spoons,
- regular
- medium
- heavy
- extra heavy

Dessert forks,
- regular
- medium
- heavy
- extra heavy

Dinner forks
- regular
- medium
- heavy
- extra heavy

Soup spoons

Fancy - sold in quantities of 12-8-6-1

Bouillon spoons
Breakfast spoons
Butter spreaders
- large
- small

Coffee spoons
Cream soup spoons
Fish forks
Ice cream forks
Ice Cream spoons
Iced tea spoons
Orange spoons
Oyster forks
Pastry forks
- large
- small

Salad forks
- large
- small

Salt spoons
Tea forks

Sterling Silver or Gorham plate (continued)

Cutlery - sold in quantities of 12-8-6-1

Breakfast knives
Dessert knives
Dinner knives
Fish knives
Fruit knives
Salad knives
Tea knives

Single Pieces

Asparagus server
Baby fork
  large
  small
Baby knife
Baby spoon
  large
  small
  bent handle
Berry spoon
Bonbon or Almond spoon
Bonbon or sugar tongs
Bottle opener
  large
  small
Bread knife
Butter knife
Butter pick
Butter pick or olive fork
Carving knife, meat
Carving fork, "
Carving steel
Carving knife, game
Carving fork, "
Carving knife, steak
Carving fork, "
Steak steel
Cheese server
Child's fork
Child's knife
Cold meat fork
  large
  medium
  small
Cream ladle
Cucumber server
Duck shears
Egg server
Food pusher
Gravy ladle
Ice tongs
Jelly server
Jelly spoon
Lemon fork
Lettuce fork
Letture spoon
Mayonnaise ladle
Napkin marker
Olive fork
Olive spoon
Pickle fork
Pie server
  large
  small
Preserve spoon
Salad fork
  large
  small
Salad spoon
Serving fork
Serving spoon
Sugar spoon
Sugar tongs
Table spoon
  regular
  medium
  heavy
  extra heavy
Tea maker
Tomato Server

SILVERWARE DEPARTMENT

Hollow Ware Sterling Silver

Almond and Bonbon dishes
Baskets
Bread Trays
Bowls and Dishes
Entree Dishes
Vegetable Dishes
Relish Dish
Cheese Holder
Goblets
Bread and butter plates
Card trays
Centrepieces and mesh
Candlesticks
Children's ware
  Cup
  Plate
  Bowl
  Porringer
  Napkin ring
  Hair brush
  Comb
  Military brush
Coffee sets
Sugar Baskets
Sugar tongs
Muffineers
Sugars and Creams
Coffee cup and saucer
Tea sets
Pitchers
Vases
Waiters
Jam jar
Syrup sets
Pepper and salt shakers
Mayonnaise bowls
Gravy boats and trays
Compotiers
Sandwich plates
Napkin rings
Photo frames
Shears
Toilet ware
Handiket set
Smokers trays
Ash trays
Match holders
Cigarette cases and box
Flasks - Beverage mixer and cup
Ice tub with glass lining
Drinking cups
Funnels
Belt buckles

SILVERWARE DEPARTMENT

Hollow Ware Gorham Plate

Baskets
- almond
- bonbon
- cake

Bells
Boat, gravy
Beverage mixer
Bowls
- berry
- mayonnaise

Boxes
- cigarette
- match

Candelabra
Candlesticks
Compotiers
Cups
- cocktail
- Coffee

Dishes
- bonbon
- butter
- cheese and cracker
- entree
- double
- fish
- meat
- muffin
- relish
- vegatable

Flasks
Goblets
Iee tubs and drainers
Plates
- butter
- bread and butter
- service
- sandwich

Pitchers
Rings, napkin
Sets
- tea
- coffee

Trays
- bread
- ash
- card

Trivets
Tureens
Waiters

BRONZE DEPARTMENT.

ART

Statuary

Familiar Historical pieces
Dancing figures
Animals
Imaginative conceptions
Children
Garden pieces and Fountain decorations
Special subjects
Busts
Tablets
Medals
Emblems and Insignias

Machine Shop

Doors
Door frames
Window frames
Partitions
Gratings
Cornices
Screens
Altar rails
Caskets
Circular stairways
Trimmings
Frames
Stairways
Special orders

Mortuary Work

Mausoleum doors
Gates
Sarcophagii
Vases
Urns
Tripods
Grilles
Cinerary Urns
Wreaths and Palms
Lion Heads
Door Handles

ECCLESIASTICAL DEPARTMENT

Alms Basons
Altar Candlesticks
Altar Crosses
Altar Desks
Altar Lights
Altar Railing
Altar Standards
Altar Vases
Apostle Spoons
Badges
Book and Box Mounts
Branches for Lights
Candelabra
Candlesticks
Cases
Chalices
Chancel Screens and Gates
Ciboria
Communion Plate
Communion Sets, Pocket
Crosses, Altar
Crosses, Processional
Crosses, Memorial
Crosiers
Cruets
Credence Patens
Crucifixes
Desks
Dossel Fittings
Eagle Lecterns
Ewers
Flagons
Flower Vases
Font Covers
Font Ewers
Fonts, Pocket
Fontlets
Grilles
Incense Boats and Spoons
Lamps
Lavabo
Lecterns
Medals
Memorial Brasses
Monstrances
Offertory Basons
Patens
Pendants
Pocket Communion Sets
Pocket Fonts
Prie Dieu Sets
Pulpits
Pulpit Desks
Pyxes
Salvers
Sanctuary Lamps
Sanctuary Standards
Screens
Signs
Spoons
Staves, Pastoral
Tabernacles
Tablets
Trays
Trowels
Thuribles
Triptychs
Vases
Wall Crosses

GORHAM MANUFACTURING COMPANY

Articles purchased	How purchased
Pure Silver and Gold	Troy ounce, pennyweight & pound
Nickel " (German)	Pound (Avoir.)
Bronze	"
Brass	"
Tin	"
Copper	"
Zinc	"
Steel	" and hundredweight
Knife blades (steel)	Dozen
Sheet metal (wrought metal)	Feet & inches (length &width) by thickness(1000th of inch)
Flannel	Pound
Raw soap	"
Pumice	"
Acids (Sulphuric, Nitric, etc.)	"
Velvet & Fringe	Yard
Leather	Square foot
Lacquer	Gallon
Oil	"
Fuel oil	Barrel - 42 gallons
Jars	Gross
Jar Caps	Hundred
Brushes	Dozen
Paper	Ream - 500 sheets
Wood	Board feet
French sand	Cask - 500 pounds
Cardboard	Ton - net
Charcoal and coal	" "

UNITS OF MEASURE USED IN MANUFACTURING.

GORHAM MANUFACTURING CO.

SILVER DEPARTMENT

LINEAR MEASURE
- Inch
- Foot
- Yard

SQUARE MEASURE
- Square Inch
- Square Foot

CUBIC MEASURE
- Cubic Inch
- Cubic foot

LIQUID MEASURE
- Pint
- Quart
- Gallon
- Barrel

TROY WEIGHT
- Pennyweight
- Ounce
- Pound

AVOIRDUPOIS WEIGHT
- Ounce
- Pound
- Hundredweight

CIRCULAR MEASURE
- Degree
- Circle

TIME
- Minute

PAPER MEASURE
- Ream

UNIT MEASURE
- Unit
- Dozen
- Gross
- Hundred

LUMBER MEASURE
- Board Foot

BRONZE DEPARTMENT

LINEAR MEASURE
- Inch
- Foot
- Yard

SQUARE MEASURE
- Square Inch
- Square Foot

CUBIC MEASURE
- Cubic Inch
- Cubic Foot

LIQUID MEASURE
- Gallon
- Barrel

AVOIRDUPOIS WEIGHT
- Ounce
- Pound
- Hundredweight
- Ton

CIRCULAR MEASURE
- Degree
- Circle

TIME
- Minute

UNIT MEASURE
- Gross

LUMBER MEASURE
- Board Foot

UNITS OF MEASUREMENT USED IN DESCRIPTION AND SALE.

GORHAM MANUFACTURING CO.

SILVERWARE DEPARTMENT

Flat Ware Pieces Sterling and Gorham Plate

In the description and sale of flat ware pieces, units of measurement are not considered to any great extent because of the variation in the different patterns, for example, the Old French pattern teaspoon is 3/8" shorter than the Dolly Madison pattern teaspoon. In general, teaspoons which are listed as Small in the catalogue are approximately 5½" in length, while those which are listed as Trade or Regular are about 6" long.

Dessert forks are usually between 7" and 7½" long while dinner forks are about 7¾" long.

Breakfast knives are between 8½" and 9" in length, dessert knives about 8¼" and dinner knives from 10" to 10½" long.

Other flat ware pieces such as butter spreaders, baby forks, jelly servers, etc. vary in measurement to such an extent that every pattern is almost individual in length.

These flat ware pieces are listed according to staples, fancy dozens, cutlery, and single pieces and are sold in quantities of 12,8,6, or 1. The price is based upon the quality, workmanship, and size of the article, sterling silver costing almost twice as much as Gorham plate and regular teaspoons costing about $2.00 a dozen more than the small teaspoons. The St. Dunstan pattern, which is very finely chased, is from $6.00 to $10.00 a dozen more than the stamped patterns.

Hollow Ware Sterling and Gorham Plate

Articles of this sort can be bought as follows:

Bonbon Dish	Diam.	6½"		Height	1¼"
Basket	"	10"	Extreme	"	6½"
Bowl	"	10¼"		"	2¼"
Compotiers	"	7-1/8"		"	6¾"
Dish	"	10-1/8"		"	1½"
Plates	"	6"			
Plates	"	6-3/8"			
Child's Cup				"	2¼"
" Porringer	"	4½"		"	1¾"
Goblets				"	6¾"
Candlesticks				"	9"
Candlesticks				"	8-9/16"
Candlesticks				"	11¾"
Vases				"	12"
Vases				"	18"
Pepper and Salts				"	4½"
Sugar Baskets	"	4½"		"	5½"
Entree Dish	"	10½"	Extreme	Diam.	14"
Bread Trays	Length	12"			

Coffee Sets

Coffee	Cap. 1-5/8 pts. Height 8¼"
Sugar	(no measurement given)
Cream	Cap. 1/2 pt.
Tray	Diam. 12"

Pitchers Cap. 4 pts. Height 7-3/8"

Frames Outside Dimensions 8-7/8"x11-3/8"

There are many other pieces of hollow ware but the pieces and measurements listed here are typical of all.

BRONZE DEPARTMENT

The products of the Bronze Art Department are priced according to the skill, time, and amount of material used in their invention and manufacture. The measurements used are according to specifications. Some articles such as doors, fittings, etc. are of standard type and may be obtained at stock prices.

Material. All work is constructed of Gorham Standard Bronze Alloys.

Construction. The work is built in accordance with, and in strict adherence to, the Gorham Standards of Bronze Construction, whether stock or special.

Doors Doors are classified, generally, as follows:

Built up doors, open back.
Built up doors, closed back.
Cast Doors, single faced, open back.
Cast Doors, single faced, closed back.
Cast Doors, double faced, built-up back.
Cast Doors, double faced, cast front and back.

Size of doors: In the manufacture of bronze pieces experience has demonstrated the necessity of establishing standard dimensions. The clear day-light or masonry jamb opening for Mausoleum doors should be three feet (3'-0") wide by seven feet two inches (7'2") high for single doors and three feet four inches (3'4") wide by seven feet two incnes (7'2") high for double doors. These dimensions have been adopted as standard and designers understand that, unless a special size door is required, it is a measure of economy to adhere to these proportions.

Other articles in bronze are manufactured according to the following dimensions:

Vases, Urns and Tripods	Height from 32½" to 48"
Grilles	25"X40½" to 40x81½"
Cinerary Urns	Height from 24½" to 29½"
Wreaths	Diam. " 15" to 62"
Palms	Length " 47" to 66"

NUMBER OF PERSONS EMPLOYED IN PLANT 865

a. Purchasing	4
b. Manufacturing	770
c. Selling	25
d. Office	66
Total	865

NUMBER OF PERSONS WHO NEED TO UNDERSTAND UNITS OF MEASURE IN MANUFACTURING.

SILVER	No.Employed	1st.Class	2nd.Class	3rd Class
Preparatory Rooms	104	1	5	98
Die Cutting	25	23	2	
Trimming & Assembling	75	1	5	69
Electro Plating	115	2	10	103
Sterling	90	1	8	81
Designing	10	8		2
Engraving	15	15		
Chasing	15	15		
Etching	5	5		
BRONZE				
Architectural	118	2	10	106
Machine Dept	150	4	9	137
Ecclesiastical Dept	10	1	7	2
BOX DEPT	38	5	8	25
Total	770	83	64	623
Percentage		11%	8%	81%

EXPLANATION OF CLASSES.

In order to separate in some degree the persons using tables of measurement from those who do not need this information to carry on their daily tasks in industry, the preceding table has been constructed by the writer. Although the general classifications of first, second, and third class are more or less indefinite in character, a finer and more detailed division would probably not prove to be much more reliable for the purposes of the study.

By 1st. class is meant those having an expert knowledge of the units of measure, and who are using that knowledge in their work. An example of this class is found in the die cutter who must be able to use the micrometer and vernier calipers and other instruments, formulae, and techniques for measuring and designing accurately all classes of work. This demands special training and a minute degree of accuracy (.0001"). It does not include the workman who simply reads an automatic gauge.

By 2nd. class is meant those having and using a knowledge of the common measures, such as linear, square, and cubic measure, and who are able to read simple blue prints. This class, in general, is composed of persons who measure inches, etc., accurately, but who have not an expert knowledge of measurement.

By 3rd. class is meant those who do not use or need to understand any units of measure. These persons are usually engaged in press work, assembling, polishing, etc. where little fundamental knowledge of measurement is required as the machines are automatic, and the process, though important, does not demand the use of measurement.

Distribution of Tolerances.

Tolerance.

"A tolerance is the difference between the limits or maximum and minimum dimensions of a given part. It may be expressed as a plus or minus, or both."

Modern mass production and organized industry demands exact dimensions, accurate to millionths of an inch on some types of work. The use of different tools called gauges measure these dimensions quickly and accurately. There are many different kinds of gauges for different kinds of work. Limit or special gauges, some of which are commonly called go-and-not-go gauges, are used in testing and inspecting, and reduce the time element to a minimum.

The American Standards Association, The American Society for Testing Materials, and other similar organizations, have endeavored to urge all concerns to adopt standard or commercial tolerances in manufacture in order to keep measurement over the years and to eliminate guess work and waste in industry. Many concerns have agreed to these standards and use them in all ordinary work. For special work, it is sometimes necessary to increase or decrease these amounts.

The Gorham Manufacturing Company in its finest work sometimes uses tolerances of plus or minus .0001". For example, it is very important that the deposit of silver in the electro-plating process be measured accurately. The expert, therefore, must be able to determine whether or not

the correct amount of silver has been used, and the limits are necessarily very fine. The common tolerance allowed in other types of silver work is plus or minus .005" or a total tolerance of .010."

In the bronze department, where considerable of the work done is on pieces over ten inches, 1/64 inch is the common tolerance, but sometimes a tolerance as large as 1/8 inch is permissable on outside dimensions.

The distribution of tolerances in the Gorham Company, therefore, ranges from plus or minus .0001" to 1/8 inch with the median of approximately plus or minus .005".

Only the expert or 1st class workman is responsible for a knowledge of tolerances.

SUMMARY.

ANALYSIS OF UNITS OF MEASUREMENT.

GORHAM MANUFACTURING CO.

LINEAR MEASURE			
Inch	300	Items.	(See list of articles manufactured, purchased and sold.)
Foot	43	"	
yard	2	"	
SQUARE MEASURE			
Square inch	2	"	
Square foot	1	"	
CUBIC MEASURE			
Cubic inch	20	"	
Cubic foot	5	"	
LIQUID MEASURE			
Pint	3	"	
Quart	1	"	
Gallon	4	"	
Barrel	2	"	
TROY WEIGHT			
Pennyweight	2	"	
Ounce	5	"	
Pound	1	"	
AVOIRDUPOIS WEIGHT			
Ounce	3	"	
Pound	10	"	
Hundredweight	2	"	
Ton (net)	4	"	
Ton (gross)	2	"	
CIRCULAR MEASURE			
Degree	2	"	
Circle	2	"	
TIME			
Minute	5	"	
PAPER			
Ream	1	"	

UNIT MEASURE		
Unit	7	Items
Dozen	10	Items
Gross	4	"
Hundred	1	"
Electric Measure		
Ampere	1	" (Electro-plating)
LUMBER MEASURE		
Board foot	2	"
Number of Items requiring one unit of measurement	447	
Number of Items requiring more than one unit of measurement, i.e., pints and inches, etc.	11	(Such as tea & coffee sets, pitchers, beverage mixers, gravy boats, etc.)
Total number of Items	458	
Number of Tables used	12	

How Items were Obtained

The number of times each item was used in purchasing, manufacturing, and selling was obtained by estimating the number of operations in which the measurement was actually used. For example, if the piece manufactured was made according to a pattern which required the use of measurement only at the time the pattern was made, this item was recorded only once, even though hundreds of similar pieces were made from the pattern.

STUDY OF A TEXTILE FINISHING INDUSTRY.

THE UNITED STATES FINISHING CO.

Providence, R.I.

There are many manufacturers of cloth who do not finish their own materials. The bleaching, dyeing, and mercerizing processes require equipment and conditions which are important and expensive enough to make the finishing a separate branch of the textile industry. The cotton manufacturer, therefore, usually sends his goods "in the gray", which means before it has been bleached and colored, to a finishing plant where the cloth is put into the condition in which it finally appears.

The United States Finishing Company is just such an industry. It does not manufacture or sell goods, but conducts its business on a service basis. The cloth and the pattern to be printed are supplied by the customer. This plant is one of seven branches, the main office being located in New York.

Bleaching. Pure, soft water and plenty of it is a prime requisite in the finishing processes. New England has many bleaching and dyeing plants because of the good water supply, as well as other advantages, such as ease and rapidity of transportation.

The cloth is bleached in large iron kiers, some of which hold 8000 pounds. This means a strip 40 miles long in some kinds of material. The cloth is boiled twice from ten to twelve hours in the caustic solution. The bleaching solution must be of exactly the right strength for the kind and amount

of material immersed and the degree of bleach to be given. The length of time goods is steeped must be accurately determined by an expert who knows the exact duration of the necessary chemical action upon the cloth.

Dyeing. Bleaching deprives the cloth of color, while dyeing gives cloth color. If the cloth is to be dyed a light color, or if it is to have colored designs on a white background, it must be bleached thoroughly before being dyed. After it has been bleached, the beauty and finish of both the color and the fabric are dependent upon those who mix the color solutions and guide the dyeing operations.

The dyestuff must be made of such a nature that the coloring matter will unite with the fiber of the cloth in order to produce the strength of color desired. It must also be set and this is done by the addition of another chemical, called a mordant. Substances of mineral origin such as salts of aluminum, chronium, iron, copper, and tin, principally, and many others to a less extent, and of organic origin, like acetic, oxalic, citric, tartaric, and lactic acid are employed as mordants. The chemical composition of the dye, the strength of the color, the temperature of the water, the length of time the cloth shall be kept in the dye bath, and the succeeding treatment of the material are problems that must be worked out by the trained chemist or dyer before the dyeing operation begins.

Printing. Roller printing is the simplist method of producing figured materials on cloth and is the method used in coloring many of our drapery and dress materials. The design of one color is engraved on a copper roller long enough to

extend across the width of the cloth to be printed. This work is very intricate and demands great accuracy of measurement. Each color must have a separate roller; therefore, if the pattern is to contain seven, eight, or more colors, there must be that number of copper cylinders in the printing machine that does the work.

The engraved rollers are accurately arranged in the printing machine each with a pan of color for that particular part of the design placed under it. The cloth is supplied to the engraved cylinders by wooden rollers covered with cloth, or brushes, which revolve in the pan of color. As these rollers or "furnishers" supply the whole surface of the engraved cylinders with color, as well as the engraved parts, the surface color has to be scraped off again, and this is done by means of a steel blade, known as the "doctor blade". The printing machine has a large iron bowl or drum covered with several layers of a course cloth called lapping and the engraved cylinders press against this surface. The cloth to be printed passes partway round the bowl of the machine and between the engraved rollers and the bowl, and thus it receives the color. The setting of the colors is extremely important in the production of satisfactorily printed materials. Printed cottons are usually run over very hot rollers filled with steam to set the colors.

THE STORY OF HOW CLOTH IS PRINTED.

The cloth is brought to the storehouse in bales which are covered with burlap and bound with metal bands. These are trucked across to another building where they are sent down a shute to the gray room. The bales are opened and after the goods are marked, the ends are sewed together. Then the cloth is rolled and measured by machine, and sent to the singeing room. Here it passes rapidly over a gas flame to remove the fine loose down and other foreign matter which might have adhered to the cloth, It is then immersed in a tank of water and sent through a pot-eye into large bins where it undergoes a souring process to prepare it for the kier room. In this room the cloth is boiled a whole day or longer in immense iron boilers or kiers containing a caustic solution to bleach it. Then it is sent to the wash room to have the caustic washed out. It is then dried and, if the goods is to be mercerized, sent to a room where it is fed into a machine which straightens the fibers of the cloth and thus mercerizes it. From here the cloth passes to the winding room where it is wound on large rollers and then sent to the roll storage until it is needed.

If the cloth is to be dyed a plain color as well as printed, it is taken to the color room and dyed by passing in and out of a dye solution, over several rollers, the lower ones being submerged in the liquid. When it is a satisfactory shade, it is removed and rolled, first passing over four or more dry cans filled with steam to dry it.

In the printing room the cloth is fed, by an apprentice called a "back-boy", into a printing machine containing one or more copper rollers according to the number of colors in the pattern to be printed on the cloth. For example, if the pattern contains yellow, orange, and brown, there will be three copper rollers.

The printer stands at the front of the machine watching the cloth constantly to see that the color is the correct shade and that the pattern is matched. During this process, which is the most important, the cloth rests on another thickness of cloth which serves as a pad. After it passes over another set of dry cans it is taken to a room where it is washed and then sent through a steaming machine to set the colors.

The goods is then starched and run tarough a tenter frame to stretch it, or through a shrinking machine to shrink it if it is shirting or non-shrinkable material, and taken to the pasting table. Here the seams in the cloth are cut out and the ends pasted together, so as not to interfere in the ironing process. Then it is dampened by means of revolving brushes and sent through a calendar machine and ironedto give it a lustre and softness.

In the folding room the cloth is inspected as it is folded by machine in yard folds. It is then counted, tagged, and wrapped, and sent to the shipping room where it is packed in cases for delivery. The wrapping paper, tape, and ticket are all supplied by the customer.

The cloth is measured automatically during almost every process by a calculating device similiar to that used in

measuring yard goods in a department store. The worker merely notices the number of yards registered and records it on the ticket accompanying the order.

An allowance of 1% or 2% according to the grade of the cloth has to be made because of the shrinkage and also because of the loss caused by the necessity of trying out the colors to be used in the pattern. If this shortage amounts to more than the percentage allowed, the loss must be made up by the United States Finishing Company.

THE UNITED STATES FINISHING CO.

Articles purchased	How purchased
Sulphuric acid - liquid	Tank car-66,000 to 100,000 pounds to a car
Tannic Acid "	Barrel - 450 lbs.
Acetic " "	Barrel - 500 lbs.
Muriatic Acid "	Carboy-120 lbs.or 10 gal.
Oxalic " crystal	Barrel- 200 lbs.
Stearic " cake	200 cakes to a case
Albumen-liquid(blood from cattle yards)	500 lbs. to barrel
Albumen " (egg)	Tin - 100 lbs.
Albone C	Carboy-120 lbs or 10 gal.
Acetine J - liquid	Barrel - 450 lbs.
Denatured alcohol	Iron drum-500 to600 lbs.
Amonia	" " 900 to 1000 lbs.
Glycerine	" " 1100 to 1200 lbs.
Glauber - common	Bag - 100 lbs.
Glauber - heavier	" 200 lbs.
Caustic Soda - Solid	Iron drum - 700 lbs.
" " liquid	Tank - 8000 lbs.
" " flakes	Drum - 350 lbs.
Cholorine	Cylinder - 150 lbs.
Soda Ash	Bag - 300 lbs.
Starches Dextrine British gum Hampton gum Corn starch Tapioca	Bag - 130 to 150 lbs.
Talc	Bag- 200 to 210 lbs.
Oils - Castor,Pine, & Corn	Barrel-billed by pound.

Articles purchased	How purchased
Kerosene oil	Tank -100 gallons
Red Oil - soap	Barrel - 50 gallons
Dyes - powder	Containers 10 lbs. to 50 lbs.
Dyes - Vat - paste or liquid	Barrel - 200 lbs.
Paper	Pound
Tape	$1\frac{1}{2}$ lbs. Cone-1000 yds.
Thread	$\frac{1}{2}$ lb. cone
Back gray cloth	Pound
Copper rollers	Unit
Doctor blades	Dozen
Wooden cases (shooks)	Unit
Coal	Ton (net)

UNITS OF MEASURE USED IN FINISHING PROCESSES.

THE UNITED STATES FINISHING CO.

1. LINEAR MEASURE

   Inches
   Yards

2. SQUARE MEASURE

   Inches

3. Cubic Measure

   Inches

4. LIQUID MEASURE

   Pints
   Quarts
   Gallons

5. AVOIRDUPOIS WEIGHT

   Ounces
   Pounds
   Ton

6. CIRCULAR MEASURE

   Degrees
   Circle

7. TIME

   Minutes
   Hours

8. UNIT MEASURE

   Unit
   Dozen
   Gross

UNITS OF MEASURE USED IN DESCRIPTION AND SALE.

THE UNITED STATES FINISHING CO.

As this industry does not manufacture articles but simply performs a service for the customer, the sales department is a little different from most concerns. The cost of the bleaching, dyeing, and printing is based upon the quality of the goods, the intricacy of the pattern as well as the number of colors used, and the amount of material to be finished. Tables, which state the cost of finishing a certain number of yards, are in the hands of the salesman. The only measurement, therefore, in which he is interested, is the number of yards in the material and the number of colors in the pattern.

NUMBER OF PERSONS EMPLOYED IN PLANT 470

a. Purchasing	3
Receiving	6
b. Finishing	437
c. Selling	9
d. Office	15
Total	470

NUMBER OF PERSONS WHO NEED TO UNDERSTAND UNITS OF MEASURE IN FINISHING

	No. Employed	1st.Class	2nd.Class	3rdClass
Preparatory Rooms				
Gray	12	1		11
Singeing	8		1	7
Bleaching	30	1	2	27
Mercerizing	6	1	1	4
Winding	30		1	29
Dye	30	1	1	28
Dry Cans	6			6
Color	20	1	2	17
Printing	60	14	6	40
Soap and Steam	20		1	19
Engraving	12	12		
Tenter Frame	28	1	1	26
Pasting	10			10
Dampening	10			10
Calender	30	1		29
Make-up (& inspection)	45	1	4	40
Packing	40	1	2	37
Power and Maintenance	20	2	6	12
Store Room	5		1	4
Trucking	15			15
Total	437	37	29	371
Percentage		8%	7%	85%

SUMMARY

ANALYSIS OF UNITS OF MEASUREMENT

THE UNITED STATES FINISHING CO.

LINEAR MEASURE		
Inch	7	Items
Yard	10	"
SQUARE MEASURE		
Inch	2	"
Foot	1	"
CUBIC MEASURE		
Inch	1	"
LIQUID MEASURE		
Pint	1	"
Quart	2	"
Gallon	9	"
AVOIRDUPOIS MEASURE		
Ounce	4	"
Pound	20	"
Ton (net)	1	"
CIRCULAR MEASURE		
Degree	1	"
Circle	1	"
TIME		
Minutes	4	"
Hours	3	"
UNIT MEASURE		
Unit	3	"
Dozen	1	"
Number of Items requiring one unit of measurement	71	

Number of Items requiring one unit of measurement	71
[1] Number of Items requiring more than one unit of measurement, i.e., yards and inches.	1
Total number of Items	72
Number of Tables used	7

[1] Number of yards to be printed and width of cloth in inches.

A STUDY OF AN INDUSTRIAL PIPING INDUSTRY.

GRINNELL COMPANY, INC.

MANUFACTURING FACILITIES THROUGH ARRANGEMENTS WITH GENERAL FIRE EXTINGUISHER COMPANY.

The Grinnell Company, sometimes known as the General Fire Extinguisher Company, is fully equipped to manufacture and sell many kinds of products. The automatic sprinkler, as a method of fire protection, is a recognized leader due to the superiority of the Grinnell head and to a firm adherence to high standards of construction. There are more Grinnell systems in use than all others combined.

Power piping work is also a specialty of the Grinnell Company. This includes the construction and furnishing of all the necessary materials in connection with the piping.

In the heating field, the Grinnell forced circulation hot water system is an economic method used in large industrial plants. The service includes expert construction and installation.

All of the piping work necessary for the supply of water, air, oil, chemical and other miscellaneous pipe lines in industrial plants may be done by the Grinnell Company and installed with proper regard to strength, straightness and proper pitch.

In making the parts necessary for its own contracting business, the Grinnell Company evolved the plan of offering these parts for sale in large quantities. Almost any type of fittings, hangers, valves, and piping supplies may be bought according to standard sizes or special specifications.

Textile drying machinery, electrical devices, and humidifying equipment are also products of this company.

There are seven Grinnell plants in North America, two of which are located in Canada. The general offices are located at 260 West Exchange Street, Providence, R.I. This study is concerned with the Providence plant, which specializes in automatic sprinklers.

Humidifying equipment, such as atomizers, humidity controls and scales, use the trade name AMCO or American Moisting Company. This is a subsidiary of the Grinnell Company. Humidifiers and other AMCO products are made in large numbers by this concern. A humidifier is a high capacity head for use where conditions require great amount and distribution of moisture for air conditioning in high studded rooms and those where high temperatures prevail due to local conditions or requirements. It is valuable where temperature and dryness of the air are great, owing to frictional heat developed by operation of cotton spinning and twisting machinery.

In the sheet metal department, there are large machines which cut and turn the edges of the copper sheets. The men engaged in this work must be able to work from templates, to read simple blue-prints, and to understand common measurements. The copper is rolled into large cylinders, then it is lapped and riveted to make a tight joining.

The interior parts of these humidifiers are made in various departments. In the foundry, bronze is used in the manufacture of the heavier portions. Three types of furnace are used, (1) electric, (2) oil, and (3) pit fires, in which

coal is used. After the parts have been cast, they are sand blasted in the cleaning room.

Turret lathes smooth and trim the different parts. Expert workers in the brass room thread and fit the smaller pieces and some of the larger sections which must be fitted accurately. They make use of different types of gauges and use the micrometer calipers. Other workers in this room do not need to use measurement as they are performing one operation, and an expert sets the machines.

The parts of the humidifier are finally assembled, tested, and regulated. It is then ready for distribution.

AUTOMATIC SPRINKLERS

For thirty years the Grinnell Automatic Sprinklers have been used as a means of fire protection. They have been reported as having extinguished thousands of fires with trivial losses which otherwise might have become very serious set backs.

There are two types of sprinklers, the soldered type link sprinklers which operate at a temperature not lower than 155 degrees F, and the silica bulb sprinklers which operate at 135 degrees F. The soldered type (the original) consists of a yoke, body, diaphragm, glass valve, main strut piece,key, hook, and deflector. A thin coating of solder which melts at different degrees according to the kind of solder used, holds the parts in place.

The silica bulb sprinkler works on an entirely different principle but uses many of the same kind of parts. The element affected by the heat is a silica bulb nearly filled with a red colored liquid. This bulb at the lower end rests on two soft copper rings which in turn are held in place by a metal button. At its upper end the bulb rests on a similar ring which is supported by a small collar. A small pin prevents an adjusting screw in the collar from becoming loose. All of the metal parts are made of bronze, selected because of its strength and ability to resist corrosion. When the head is exposed to rising temperature, the liquid in the bulb expands and shatters the bulb. This loosens the parts and releases the water, thus obtaining prompt and efficient response of sprinklers.

Several gauges are used by the expert in the construction of automatic sprinklers. In order to comply with the insurance company regulations, each part must be tested thoroughly and examined periodically by an insurance inspector. Gauges which become worn and inaccurate must be replaced.

The inspectors of these parts are working with go-and-not-go gauges constantly, but on the other hand they are not concerned with the actual measurement as the gauge is all that is necessary. The inspector may or may not know that he is working with measurements as fine as .001" or, in some cases, .0001".

ARTICLES MANUFACTURED.

GRINNELL COMPANY INC.

PIPE

Wrought pipe, Boiler Tubes, Wrought Couplings and Nipples
Brass Pipe and Nipples, Fabricated Piping Material, Arco
Metal Pipe, Couplings and Nipples
Cast Iron Flanged - Bell and Spigot

FITTINGS

Screwed Fittings, Standard Cast Iron
Branch Tees, Cast Iron
Screwed Fittings, Extra Heavy Cast Iron
Screwed Fittings, Cast and Drop Forged Steel
Floor and Ceiling Plates
Unions and Union Fittings
Malleable Iron Fittings
Railing Fittings
Bronze Screwed and Flanged Fittings
Long Turn or Sprinkler Fittings - Drip or Drain Tees
Drainage Fittings
Flanged Fittings, Standard Cast Iron
Flanged Fittings, Extra Heavy Cast Iron
Flanged Fittings, Special - Cast or Fabricated

FLANGES

Drilling Flanged Valves
Bolts, Nuts and Gaskets

SOCKET FITTINGS

Socket Clamps

HANGERS AND SUPPORTS

EXPANSION JOINTS

FIRE PROTECTION SPECIALTIES

Automatic Sprinklers - Solder Type and Bulb Type

VALVES

Grinnell and Standard
Pratt & Cady
Reading
O.I.C.
Kennedy
Columbian
Foot Valves
Accessories
Blow-off Valves - Everlasting
Cocks

STEAM SPECIALTIES, ETC.

Gauge Cocks, Gauges, Thermometers
Safety and Relief Valves,
Safety Valve Discharge Elbows
Reducing Valves, Steam Traps
Grinnell Thermoliers - (Unit Heaters)
Thermoflex Specialties
Air Traps, Radiator Valves, Traps, Air Valves
Vents, etc.
Ejectors, Injectors

MISCELLANEOUS SPECIALTIES

Pipe covering, Insulation, etc.

TOOLS

Pipe Vises, Cutters, Taps, Reamers
Wrenchs
Chain Pipe Tongs
Die Stocks
Asbestos Lead Joint Runners

AMCO PRODUCTS

Humidifiers - Junior, Standard, Fan, Simplex,& Ampex Types
Atomizers- Self Cleaning and Plain
Dampeners
Hand Sprayers
Humidity Controls - Air & Electric
Psychrometers - Mechanical & Electric
Humidity Scale

GRINNELL COMPANY INC.

Articles Purchased	How Purchased
Pipe	1000 ft.(in lengths of 18 to 22 ft. Standard sizes ½',¼',etc.
Pig Iron (specification) Hard or soft composition	Ton (net)
Steel Bars Sheet Bars	Pound (Standard lengths 16' to 18')
Copper	Pound
Tin	"
Zinc	"
Lead	"
Nickel	"
Aluminum	"
Cadmium	"
Brass	"
Coke	Ton (Gross)
Coal	" (Net)
Rubber Moulded Goods (for gaskets)	Pound
Baklite	"
Oils (Cutting & lubricating)	Gallon
Linseed oil	Pound
Fuel oil	Barrel(42 gal.)
Platinum	Troy ounce
Brazilian quartz tubing	Feet (diameter according to specification ½,1/8,"
Gold Beaters' skin	Yard
Asbestos	Pound
Graphite	Pound

UNITS OF MEASURE USED IN MANUFACTURING

GRINNELL COMPANY INC.

1. LINEAR MEASURE
   - inches
   - feet
2. SQUARE MEASURE
   - inches
   - feet
   - yards
3. CUBIC MEASURE
   - inches
   - feet
4. LIQUID MEASURE
   - gallons
5. TROY WEIGHT
   - ounce
6. AVOIRDUPOIS WEIGHT
   - ounces
   - pounds
   - hundredweight
   - ton
     - gross
     - net
7. CIRCULAR MEASURE
   - degrees
   - circle
8. TIME
   - seconds
   - minutes
9. UNIT MEASURE
   - unit
   - dozen
   - gross

List of gauges used in measuring

Micrometer Caliper
Vernier "
Steel rules
Steel Caliper rule
Bevel Protractor
Steel squares
Thread tool gauges
Vernier height gauges
Vernier depth gauges
Micrometer depth gauges
Spring depth gauges
Universal surface gauges
Planer and Shaper gauges
Screw Pitch gauge
Thickness gauge
Center gauge
Standard internal cylindrical gauges
Standard external cylindrical gauges
Standard taper cylindrical gauges
Limit gauge
Special gauges

UNITS OF MEASUREMENT USED IN DESCRIPTION AND SALE

GRINNELL COMPANY INC.

Although a great deal of the work which is done at the Grinnell Company is performed according to detailed specifications, standard fittings, valves, etc. may be obtained from stock. Because of the necessity of accuracy the dimensions in the description and sale must be of such a nature that the customer may obtain the correct size and type of product. In some cases one dimension, the inch or parts of the inch is sufficient, but in other cases it is necessary to specify two or more dimensions or measurements.

In order to illustrate the complexity of the measurements and the need of definite specifications, the following table is given. Almost every article which is manufactured is described in this manner.

Arco Metal Pipe and Couplings

Arco Metal Pipe - Threaded

Size Inches	Weight Per Foot	Wall Thickness Inches	Threads per Inch
1½	3.5	.200	11½
2	4.7	.218	11½
2½	6.7	.276	8
3	9.2	.300	8
4	13.0	.337	8
5	18.4	.375	8
6	26.8	.432	8

Unless otherwise specified threaded pipe is shipped in approximately six foot lengths.

The salesmen sell practically all their products from catalogue. There is an attempt being made in this company to employ sales engineers, men who can sell and install. Up to the present time, however, there is but one sales engineer employed. General men, or men who understand thoroughly how to assemble and install Grinnell products, are sent by the company, to the building or plant, after the salesman has obtained the order. These men translate the specifications sent in into a satisfactorily finished piece of work.

NUMBER OF PERSONS EMPLOYED IN PLANT 439

a. Purchasing	2
Assistants	4
b. Manufacturing	365
c. Selling	7
d. Office	61
Total	439

NUMBER OF PERSONS WHO NEED TO UNDERSTAND UNITS OF MEASURE IN MANUFACTURING.

	No. Employed	1st. Class	2nd Class	3rd Class
Sheet Metal	40	4	5	31
Basement	48	1	1	46
Brass Room	36	5	5	26
Sprinkler	50	1	1	48
Brass Foundry	74	1	3	70
Bulb Sprinkler	25	1		24
Carpenter Shop	11	4		7
Assembly, Enameling	43	1	12	30
Tool Room	11	5	6	
General, Inspection and Maintenance	27	12	11	4
Total	365	35	44	286
Percentage		9%	13%	78%

DISTRIBUTION OF TOLERANCES

Because of the demand for a high grade fitting combined with utility and strength, the parts manufactured by the Grinnell Company must be accurate and according to standard. There are certain Manufacturer's Standards to be followed if the customer is to be enabled to order stock products. For example, the material, dimensions, number of threads, etc., must all conform to these standards. Certain tolerances or limits are also specified. These tolerances are of different amounts according to the type and use of the part.

A tolerance of plus or minus .001" is allowed on fine work, of plus or minus .003" on other work, but on most of the parts the commercial tolerance of plus or minus .005" is accurate enough. A limit of plus or minus 1/32 inch is allowed on center to contact heavy cast iron fittings for sizes up to and including 10 inches, and plus or minus 1/16 inch on sizes larger than 10 inches. Furthermore, plus or minus 1/16 inch is allowed on all contact surface to contact surface dimensions for sizes up to and including 10 inches and plus or minus 1/8 inch on sizes larger than 10 inches. On larger pieces of sheet metal work, plus 1/64 inch is allowed to pass inspection. The approximate median, is probably about plus or minus .005".

In the manufacture of these parts, the majority of the workmen do not have gauges nor do they use these tol-

erances. For the most part, the work is done according to a pattern, or the machine, which is set, turns out the parts automatically. The inspector examines the result and tests the accuracy of the dimensions by means of a special go-and-not-go gauge. Some inspectors are first class workmen while others, who merely inspect according to the gauge, discarding those which do "not-go", are second class workers.

SUMMARY

ANALYSIS OF UNITS OF MEASUREMENT.

GRINNELL COMPANY INC.

LINEAR MEASURE	
Inch	223 Items
Foot	2 "
SQUARE MEASURE	
Square inch (See foot note)	
Square foot	
Square yard	
CUBIC MEASURE	
Cubic inch	3 "
Cubic foot " " "	
LIQUID MEASURE	
Gallon	4 "
TROY WEIGHT	
Ounce	1 "
AVOIRDUPOIS MEASURE	
Ounce	7 "
Pound	14 "
Hundredweight	6 "
Ton	
net	3 "
gross	1 "
CIRCULAR MEASURE	
Degree	11 "
Circle	5 "
TIME MEASURE	
Second	14 "
Minute	6 "
UNIT MEASURE	
Unit	5 "
Dozen	3 "
Gross	4 "
	312 "

Total number of Items requiring one unit of measurement.	312
Items requiring two units of measurement.	
Inch & foot	12
Inch & square inch	2
Inch & square foot	4
Inch & degree	26
Inch & pound (size in inches, pounds steam pressure)	316
Items requiring three units of measurement.	
Inch, pound, degree (size, pressure & angle of elbows)	33
Inch, foot, pound	17
Inch, square inch, pound	2
Inch, square yard, pound	2
Inch, pound, gallon	2
Inch, square foot, pound (size, grate area, & pressure of Lock Up Safety Valve)	1
Items requiring four units of measurement.	
Inch, foot, gallon, pound (Automatic injectors)	1
Inch, pound, gallon, cubic foot (Water lifters)	1
Items requiring five units of measurement.	
Inch, foot, pound, gallon, square foot (Steam Trap)	1
Inch, square foot, pound, second, minute (Foam Tank)	1
Foot, cubic foot, pound, minute, hour (Thermoliers - Air velocity, ft. per min.; air delivery, cu.ft. per min.; condensation, lbs. per hr. - Standard Units)	2
Total number of Items	735
Number of Tables used	9

Foot Note.

Square Measure and Cubic Foot used only in items requiring more than one unit of measurement.

A STUDY OF A JEWELRY MANUFACTURING INDUSTRY.

B. A. BALLOU & COMPANY INC.

PROVIDENCE R. I.

The B.A.Ballou Company, manufacturing jewelers, was founded by Barton A. Ballou nearly 60 years ago. This is one of the oldest and most reliable jewelry concerns in the city of Providence.

The persons employed in this industry range from the highly skilled workman to operators of automatic machines, each performing a definite and necessary part of its production. The designer makes a sketch of the article, and the toolmaker makes the steel forms and necessary tools for the stamping process. There are several other operations, such as bending, soldering, coloring, and finishing before the article is ready for use.

The steel die is one of the greatest aids to the jewelry industry. It is by this means that the production of large quantities of jewelry is made possible in a comparatively short time at a minimum cost.

Pieces of jewelry are stamped as one piece or in several sections, and then assembled by hand. The effects obtained in this manner are difficult to distinguish from the more expensive hand wrought jewelry.

The hub is a perfect model in steel of the design to be produced. It is used to produce the die or negative form from which the article is stamped in gold, silver or other metals. After the hub is cut into the desired form, it is hardened and tempered, and, by means of a drop press it is

driven into a large piece of steel called the die. Sometimes the hub is used in stamping, but often it is non-essential. The die or negative form may also be cut by hand.

In cutting a hub, 1/8" margin is allowed all around the design for average work, but if the designs are to be deeply cut or if they have large flat surfaces ¼" margin should be allowed. The depth or thickness of a hub is about 1" for small work and 1¼" or 1½" for large work. About 3/8" margin is allowed on small hand cut dies, while large or deeply cut dies have a margin from ½" to 1½".

The force is a positive form, fastened to the jack or the drop press, to help force the gold, silver or other metal into the die. This force closely resembles the hub but does not have such finish as a hub.

The die is very carefully adjusted by toolsetters so that the force centers over the die. This requires accurate measurement. The metal to be used for stamping is cut into pieces larger than the sunken portion of the die. The piece is placed squarely in the center of the die, the hammer strikes the blow and stamps the pattern.

Gold is the most malleable of all metals. It is also extremely ductile - one grain may be drawn into a wire 500 feet long and it has been hammered into leaves less than a millionth of an inch in thickness. Gold as well as silver is bought from banks or refiners and assayers.

Gold better than 18-karat is seldom used in the manufacture of jewelry, and then only on special order work.

An 18-karat alloy used in fine work is made of 18 parts gold, 4 parts silver and 2 of copper. This is a very rich yellow.

A very hard 14-karat alloy, suitable for bracelet snaps, pin tongue stems or stiffening pieces, is, fine gold, 14 parts; silver, 5 parts; copper, 5 parts.

A 10-karat green gold alloy is,fine gold, 10 pennyweights; silver, 11 pennyweights; copper, 3 pennyweights.

There are different kinds of gold finishes, such as white gold, green gold, Roman gold, etc., and these are determined by the proportion of metals used in the alloy.

In melting gold for wire, scrap gold combined with new gold is usually used; the reason being that a harder and tougher wire is obtained.

Many different metal gauges are used for measuring the thickness of the stock. No standard exists, but the Browne & Sharpe wire gauge is known by all dealers in America, and therefore, it is important to give the name and number of the gauge in purchasing baser or precious metals.

Baser metals, such as copper or brass, are sold in sheets, while precious metals may be purchased by the ounce or cut to specific size. The thickness is measured by the slot the metal or wire fits into. For example, 20 gauge stock is .031961 or .032 inch, while 8 gauge stock is .12849 or .129. Number 36 stock, the finest on most gauges, is .005 inch.

B. A. BALLOU & COMPANY INC.

ARTICLES MANUFACTURED

JEWELRY

- Necklaces
  - Gold Bead
  - Silver Bead
  - Crystal Bead
  - Composition Bead
  - Enamel
- Neck Chains
- Lavalieres
- Lingerie Clasps
- Lingerie Pins
- Tie Clasps
- Tie Pins
- Soft Collar Pins
- Safety Pins
- Sport Pins
- Cuff Pins
- Cuff Links
- Belt Chain Clips
- Bill Clips
- Spans
- Identification Tags
  - " Bracelets
  - " Anklets
- Charms
- Bobbie Pins
- Hair Ribbon Clasp
- Brooches
- Bracelets
- Buckles
- Emblem Pins
  - " Buttons
- Bar Pins
  - Engraved
  - Enamelled
  - Pierced
  - With Stones
- Mourning Jewelry

JEWELER'S FINDINGS

- Pin Stems
- Catches
- Joints
- Spring Rings
- Swivels
- Clasps
- Ball Tips
- Pendant Bails
- Pendant Mountings
- Bracelet Locks
- Gold Beads
- Silver Beads
- Rivet Wire
- Guard Chains
- Numerals
- Link Connections
- Pendant Loops

B. A. BALLOU & COMPANY INC.

ARTICLES PURCHASED	HOW PURCHASED
Platinum	Pennyweight
Pure Gold	Troy ounce
Silver	" "
Rolled Gold Plate	" "
Gold & Silver Tubing	" "
Plate Wire	" "
Fancy Wire	" "
Nickel Silver	Pound (Avoirdupois)
" Brittania	"
Copper	"
Zinc	"
Tin	"
Brass	"
Steel	"
Acids	Pound & Gallon
Oil	Barrel(Billed by Gallon)
Lead	Pound
Lacquer	Gallon
Soap	Pound
Ink	Quart
Files	Dozen
Drills	Dozen
Machine Parts	Unit
Screws (Wood & Machine)	Gross
Nuts & Bolts	Gross
Beads	Gross

Stones	Gross
Cyanide of Potassium	Pound
Oakite	"
Borax	"
Solders	
Gold(different karats)	Troy Ounce
Silver (Easy and Hard Running	" "
Soft	Pound
Elastic	Yard
Ribbon	"
Thread	"
Silk Cord	"
Foxtail Chain	Foot
Needles	Dozen
Sawdust	Pound
Waste	Pound
Cards for Mounting	Thousand
Bill Heads	"
Order Sheets	"
Master Cards	"
Travel Order Cards	"
Record Cards	"
Envelopes	"

UNITS OF MEASUREMENT USED IN MANUFACTURING.

B. A. BALLOU & COMPANY, INC.

LINEAR MEASURE

Inch

Foot

Yard

SQUARE MEASURE

Inch

CUBIC MEASURE

Inch

LIQUID MEASURE

Ounce

Quart

Gallon

Barrel

TROY WEIGHT

Grains

Pennyweight

Ounce

AVOIRDUPOIS WEIGHT

Ounce

Pound

CIRCULAR MEASURE

Degree

Circle

TIME

Minute

UNIT MEASURE

Unit

Dozen

Gross

UNITS OF MEASUREMENT USED IN DESCRIPTION AND SALE

B. A. BALLOU & COMPANY INC.

In this concern, the writer has found, as is the case in many other jewelry firms, that the salesmen do not sell from a catalogue but carry a sample line of goods. The customer as a rule desires to see the different qualities and finishes of the gold or other metals. This could not be accomplished by the use of the catalogue alone.

Beside the article on the sample card is the stock number, and different qualities of gold in which it may be obtained. The salesman, in filling out the order blank, states the stock number, the quality of gold desired and the quantity. Usually, manufacturing jewelers do not sell retail.

Jeweler's findings, such as pin stems, swivels, catches, etc., are sold by the dozen or gross. When the bill is sent to the customer, the quantity, in units, and the weight, in pennyweight, are both stated as the price is determined upon both these factors.

NUMBER OF PERSONS EMPLOYED IN PLANT		155
a. Purchasing	2	
b. Manufacturing	132	
c. Selling	9	
d. Office	12	
Total	155	

NUMBER OF PERSONS WHO NEED TO UNDERSTAND UNITS OF MEASURE IN MANUFACTURING

	No. Employed	1st. Class	2nd Class	3rd Class
Designing & Toolmaking	15	10	3	2
Toolsetting	5	4	1	
Press & Bench Work	40	1	2	37
Enamelling	7	1		6
Melting	2	1	1	
Soldering & Assembling	30	2	4	24
Polishing & Annealing	8			8
Coloring	5	1	1	3
Carding & Shipping	20	1	1	18
Total	132	21	13	98
Percentage		16%	10%	74%

Distribution of Tolerances.

The distribution of tolerances in this concern is from .0001 inch in measuring platinum, gold, and silver to 1/8 inch and ¼" in measuring the lengths of bracelet links and neck chains. For example, in cutting off links for bracelet lengths and neck chains, the girl measures off the number of inches desired by holding the links of chain against a yard stick which is nailed to the bench. If the length is somewhat longer than the required number of inches, the difference is allowed.

In drawing wire to a specified thickness or gauge, however, much finer measurements are necessary and the tolerance is very small.

The most frequent tolerance is about .003".

SUMMARY

ANALYSIS OF UNITS OF MEASUREMENT

B. A. BALLOU & COMPANY INC.

LINEAR MEASURE		
Inch	52	Items
Foot	2	"
Yard	5	"
SQUARE MEASURE		
Square inch	5	"
CUBIC MEASURE		
Cubic inch	3	"
LIQUID MEASURE		
Ounce	2	"
Quart	3	"
Gallon	5	"
Barrel	2	"
TROY WEIGHT		
Grain	5	"
Pennyweight	11	"
Ounces	16	"
AVOIRDUPOIS		
Ounce	3	"
Pound	19	"
Ton (net)	1	"
CIRCULAR		
Degree	2	"
Circle	3	"
TIME		
Minute	6	"
UNIT		
Unit	9	"
Dozen	5	"
Gross	7	"
Total	166	"

Number of Items requiring one unit of measurement	166
[1] Number of Items requiring more than one unit of measurement, i.e., gross and pennyweight	1
Total number of Items	167
Number of Tables used	9

[1] In billing jeweler's findings.

A STUDY OF A WINDING MACHINE INDUSTRY.

UNIVERSAL WINDING COMPANY.

Cranston, R.I.

The Universal Winding Company manufactures machines for winding fibrous material, for market or for use in mills, and also machines for winding electrical coils. The plant covers approximately 25 acres with nearly 10 acres of floor space in use, and the employees number over 1000.

In 1893, a corporation under the name "Universal Winding Company" was organized to develop the business begun by Mr. Joseph R. Leeson. At the present time, nearly 50 styles of machines, fully protected by patents, have been sold wherever textile machinery is used. There are more than 160 different attachments on these machines, thus making it possible to wind anything windable.

Although winding machines have been used successfully in almost every branch of the textile and fabric industries, the cotton, wool, and silk industries are, in point of volume, the most important. Winders are used at several points in each of these industries and, because of the difference in the material handled, more than one machine and more than one type of equipment for each are necessary to meet the demands imposed. Each machine is concerned with four main operations; (1) the spindle, which revolves the container upon which the fiber is wound, the power coming from outside the machine, (2) the traverse and gainer mechanisms which control the distribution of yarn on the container, (3) the tension and pressure attachments which condition the package as it is built up,

making it uniform throughout, and (4) the supply.

Each machine is limited to certain types of work, so that each shall perform perfectly. In deciding which machine and what type of equipment is needed for that machine in performing a particular kind or grade of work, four facts must be known; (1) the nature of the material, that is, size, strength, hardness, etc., (2) the form of package into which it may be wound, (3) the number of ends to be wound, and (4) the form of container which will be used as a supply.

The No.50 winding machine is typical of several other winding machines manufactured by the Universal Winding Company, although the size and form of the parts may be different. A combination of this machine which is most familiar is the nutaper coner 9° 15" taper, fitted with 6" cam, and steel finger tension and over-end supply. This is the standard equipment for winding a supply for knitting machines using cotton yarn. By changing the cone tube holder and cam for short traverse winding, the machine is made ready to wind cones for the cotton interweaving which is used to insulate coils, and also for winding cotton or silk splicer cones. These splicer cones form an auxiliary supply on the knitting machine and are brought into play in knitting the heel and toe of stockings, where reinforcement is necessary.

The regular coner, 5° 7" taper, is also used to wind a supply for knitting machines, and as a standard form for shipping yarn from the commercial spinner to be used in other branches of the industry. The familiar package of store string is usually wound with this equipment.

The No.90 machine is of a somewhat different type than the No.50, although it has some points in common. It winds the shuttle supply for all kinds and varieties of cotton,wool, silk, hemp, and other pile fabrics, and requires an almost endless variety of equipment to meet all conditions. For example, there have been spindles made to more than 750 different specifications and sizes. Approximately 75 attachments are available in connection with the machine. The filling for practically all of the woven silk in the United States and other countries is wound on this machine.

The No.7 machine is a tube winder for winding heavy cords and ropes up to ½ " diameter and in packages making a maximum length and diameter of 16". Packages produced on this machine weigh from 30 to 60 pounds each, depending upon the nature of the material.

Special machines are used in winding many forms of electrical coils. No.98 is a heavily constructed machine for winding coils up to 14 inches in diameter with a maximum length of 12 inches in the spool-wind form. It is easily adjustable for various sizes of wire and is fitted with a counter for measuring the turns of the wire.

No. 96 machine winds coils for electrical meters of all descriptions, telephone and telegraph coils, transformers, ignition coils, and radio coils of various types. All coils not exceeding 3-5/8 inches long and 6 inches in diameter are wound on this machine when the wire does not exceed No. 18 B. & S. gauge. These are the only self-supporting electrical coils known to exist.

ARTICLES MANUFACTURED

UNIVERSAL WINDING CO.

Textile Winding Machines

- Cotton
- Wool and worsted
- Silk
- Thread (For winding commercial packages)
- Package dyeing (For winding packages to place in dyeing kiers)
- Carpet Warp
- Cordage and twine
- Ribbon and tape

Electrical Coil Winding Machines

UNIVERSAL WINDING COMPANY.

Articles Purchased	How Purchased
Machine Parts	
Nuts	100
Bolts	100
Screws	
Cap	100
Machine	Gross
Wood	Gross
Drills & Files	Dozen
Oil	
Cutting	Gallon
Lubricating	"
Auto	"
Fuel	Barrel(42 gallons)
Emery	
Powdered	Pound
Sheet	Quire
Emery Wheels	Unit
Pig Iron	Ton (gross)
Steel	Hundredweight
Lumber (for crating machines)	Board Feet(7/8" domestic, 1-1/8" foreign thickness)
Shooks	Unit
Coke	Ton (net)
Bronze	Pound
Lead	"
Aluminum	"
Metal Slitting Saws	Unit(according to specification from 2½" diameter to 8" and from 1/16" to 3/16" thickness)
Cones	
Wood and Paper	1000
Paper	Pound & Sheet
Blue Print Material	
Metal stampings	100
Forgings	Unit
Porcelain Guides	1000
Machine Guards	Unit
Leather Belting	Foot
Ball Bearings	Unit

UNITS OF MEASURE USED IN MANUFACTURING.

UNIVERSAL WINDING COMPANY.

LINEAR MEASURE

Inch
Foot
Yard

SQUARE MEASURE

Inch
Foot

CUBIC MEASURE

Inch
Foot

LIQUID MEASURE

Quarts
Gallon

AVOIRDUPOIS WEIGHT

Ounce
Pound
Hundredweight

CIRCULAR MEASURE

Degree
Circle

TIME

Minute

PAPER MEASURE

Sheet
Quire

UNIT MEASURE

Unit
Dozen
Gross
Hundred

LUMBER MEASURE

Board Foot

NUMBER OF PERSONS EMPLOYED IN PLANT 1096

a. Purchasing	4
b. Manufacturing	957
c. Selling	18
d. Office	117
Total	1096

NUMBER OF PERSONS WHO NEED TO UNDERSTAND UNITS OF MEASURE

IN MANUFACTURING

	No. Employed	1st. Class	2nd. Class	3rd. Class
Assembling	48	1		47
Bench	55	1		54
Boxing	18	1		17
Bracket	7		7	
Drafting	30	15	15	
Drills	39	1	8	30
Experimental	9	9		
Engine (Maintenance, etc.)	33	1	14	18
Frame Machine	11	1	10	
Foundry	203	8	15	180
Garage	10		1	9
General	20	10	10	
Hardening	8	1		7
Inspection	51	2	2	47
Lathes	49	3	6	40
Millers	32	2	5	25
Movemen	19		1	18
Millrights & Electricians	12	6	6	
Polishing	14		1	13
Punch Press	23		2	21
Restaurant	4		1	3
Repair	9	2	7	
Roundmen	21	2	19	
Stores	31	1	10	20
Special Machine	25	15	10	
Shipping	18		1	17
Sweepers	23			23
Screw Machine	55	4	5	46
Toolmen	46	20	16	10
Tool Crib	7			7
Winding	2	2		
Speed Lathes	20	1		19
Point Standard	5	2	3	
Total	957	111	175	671
Percentage		12%	18%	70%

Distribution of Tolerances.

Tolerances in the Universal Winding Company are of different ranges in the different departments.

In the lathe and automatic screw machine department, tolerances range from plus or minus .001" to plus or minus .005". The foreman and assistant forman set the machines and are the only ones involved in the tolerance. As many as 5 operations are performed on one machine in this department.

The range of tolerances in the milling department is from plus or minus .001" to plus or minus .010", but plus or minus .001" is the tolerance commonly allowed. Only two persons are involved, the foreman and assistant, as, after the machines are set up, the machine works automatically.

In the tool room, one half of the workers use and need to understand fine measurement. They work in parts of an inch almost entirely. These tolerances range from plus or minus .0001" to plus or minus .002", with plus or minus .002" in common use.

Those who are engaged in special work, that is, in making new parts for machines or new machinery are,for the most part, highly skilled and able to use and understand instruments of fine measurement. These men work with tolerances from plus or minus .0005" to plus or minus .015", with plus or minus .012"used commonly.

In the inspection department, where each part is gauged for accuracy, the persons employed, most of whom are girls, try each part in the go-and-not-go special gauge. The parts which do not "go", that is, those which fit the "not-go",

are discarded, and later returned to the different departments to be corrected. This mass inspection requires accuracy and dexterity rather than a knowledge of measurement or a knowledge of tolerances. The foreman or head inspector and his assistant are practically the only persons who are involved in the understanding of these tolerances.

In the foundry where the large parts of the machines are cast, a larger tolerance is naturally allowed according to commercial or standard tolerances. In general, plus or minus 1/32" is allowed up to 10", and plus or minus 1/16" on pieces larger than 10".

The entire distribution of tolerances in this industry is from plus or minus .0001" to plus 1/16" with an approximate median of plus or minus .003" on small pieces or parts and plus or minus .019" on larger pieces.

SUMMARY

ANALYSIS OF UNITS OF MEASUREMENT

UNIVERSAL WINDING COMPANY.

LINEAR MEASURE		
Inch	754	Items (Parts and attachments of machines)
Foot	38	"
Yard	46	"
SQUARE MEASURE		
Square inch	34	"
Square foot	14	"
CUBIC MEASURE		
Cubic inch	25	"
Cubic foot	20	"
LIQUID MEASURE		
Quart	3	"
Gallon	4	"
AVOIRDUPOIS		
Ounce	32	"
Pound	55	"
Hundredweight	1	"
Ton (net)	1	"
Ton (gross)	1	"
CIRCULAR MEASURE		
Degree	7	"
Circle	9	"
TIME		
Minute	30	"
PAPER MEASURE		
Sheet	2	"
Quire	1	"
UNIT MEASURE		
Unit	30	"
Dozen	2	"
Gross	2	"
Hundred	7	"
LUMBER MEASURE		
Board feet	2	"
Total	1120	

Number of Items requiring one unit of measurement	1120
[1] Number of Items requiring two units of measurement	
Foot & Inch	162
Degree & Inch	14
Yard & Minute	48
Total number of Items	1344
Number of Tables used	10

[1] Ft. & In.- Larger parts of machines, such as bases, troughs, shelves, etc.

Degree & In.- Shape and size of cones used in machines

Yd. & Min.- Speed of machine in winding, i.e., 150 to 300 yds. per minute.

SUMMARY OF ITEMS OF UNITS OF MEASUREMENT FOR FIVE INDUSTRIES STUDIED.

	Gorham	U.S. Finish.	Grinnell	Ballou	U. Wind.	Total
LINEAR MEASURE						
Inch	300	7	223	52	754	1336
Foot	43		2	2	38	85
Yard	2	10		5	46	63
SQUARE MEASURE						
Square Inch	2	2		5	34	43
Square Foot	1	1			14	16
CUBIC MEASURE						
Cubic Inch	20	1	3	3	25	52
Cubic Foot	5				20	25
LIQUID MEASURE						
Pint	3	1				4
Quart	1	2		3	3	9
Gallon	4	9	4	5	4	26
Barrel	2			2		4
TROY WEIGHT						
Grain				5		5
Pennyweight	2			11		13
Ounce	5		1	16		22
Pound	1					1
AVOIRDUPOIS						
Ounce	3	4	7	5	32	51
Pound	10	20	14	19	55	118
Hundredweight	2		6		1	9
Ton (Net)	4	1	3	1	1	10
Ton (Gross)	2		1		1	4
CIRCULAR						
Degree	2	1	11	2	7	23
Circle	2	1	5	3	9	20
TIME						
Second			14			14
Minute	5	4	6	6	30	51
Hour		3				3
						2007

	Gorham	U.S. Finish.	Grinnell	Ballou	U. Wind.	Total
UNIT MEASURE						2007
Unit	7	3	5	9	30	54
Dozen	10	1	3	5	2	21
Gross	4		4	7	2	17
Hundred	1				7	8
PAPER						
Sheet					2	2
Ream	1				1	2
LUMBER MEASURE						
Board Foot	2				2	4
ELECTRIC MEASURE						
Ampere	1					1
TOTAL						2116
Number of Items requiring more than one unit of measurement	11	1	423	1	224	660
TOTAl NUMBER OF ITEMS MEASURED	458	72	735	167	1344	2776

It seemed unnecessary to list in detail the 2776 items in these five industries. In order to illustrate what some of these are, a few of the most frequently used units of measurement, and a representative list of each, are given on the following pages.

INCH

Height of silver dish
Diameter of " "
Length of bread tray
Height of goblets
Height of candlesticks
Length of baby spoon
Length of baby fork
Length of gravy boat
Length of teaspoon
Length of spoon handle
Length of bowl of spoon
Width of spoon handle
Width of bowl of spoon
Height of coffee pot
Height of creamer
Width of cloth
Size of pattern on roller
Spacing of pattern on roller
Diameter of pipe, elbows, tees and crosses, reducers, couplings, bushings, plugs, unions, and flanges.
Thickness of pipe, etc.
Length of rods
Length of screws

Thickness of steel die
Length of pins
Length of chains
Diameter of beads
Length of lingerie pins
Length of bar pins
Diameter of gold wire
Diameter of spring rings
Width of bracelets
Length of pin stems
Length of bobbin
Height of cone
Length of tension
Width of tension
Length of traverse and gainer mechanisms
Length of pressure attachments
Diameter of discs
Length of guides
Width of belts
Length of cop holder
Diameter of Coils
Size of packages

POUND

German silver
Bronze
Brass
Pumice
Acids
Albumen
Glauber
Caustic soda
Soda ash
Starches
Oils

Paper
Tape
Cloth
Brittania
Steel
Soap
Soft solder
Asbestos
Graphite
Rubber moulded goods
Powdered emery

FOOT

Length of pieces of sheet metal
Length of strips of German silver
Length of bronze tablets
Height of bank grilles
Length of bronze caskets
Height of large statues
Length of pipe
Depth of tank

Length of foxtail chain
Length of brass strips
Length of machine
Height of " stands
Length of trough
Length of belting
Length of steel rods
Length of supply holder
Length of creel
Diameter of revolving drum

YARD

Length of velvet
Length of fringe
Length of cloth
Length of gray cloth
Length of tape
Length of thread
Length of elastic
Length of ribbon
Length of silk cord

Amount on yarn cone, knitting cone, warping cone, emulsion cone, cotton bobbin, worsted loom bobbin, filling cone, splicer bobbin, and braider cop
Amount on Franklin package, twine package, heavy cord package, and rope package

UNIT

Flatware pieces
Hollow ware
Statues
Doors
Grilles
Ecclesiastical pieces
Copper rollers
Docter blades
Thermometers
Thermoliers

Humidifiers
Atomizers
Dampeners
Machine parts
Gold bead necklaces
Lavaliers
Emery wheels
Metal slitting saws
Machine guards
Machines

CUBIC INCH

Sheet metal
Bronze busts
" statuary
" tablets
" caskets
" gates
Wall crosses
Doors
Cornices
Capacity of kiers

Capacity of extinguisher
" of foam tanks
Cast iron flanges and fittings
Steel die
Electro-plating
Cast iron parts
Oil reservoir
Emulsion trough
Wooden cases

OUNCE

Weight of spoon
Oil, lacquer, acid, soap and pumice
German silver, bronze, brass, copper, zinc, and cadmium

Dyes, mordants
Albumen, Albone
Glauber, glycerine
Soda and cholorine - ?
Cyanide of potassium
Soft solder

MINUTE

Electro-plating flatware
" " hollow ware
Gilding
Melting metals
Dyeing
Printing
Mercerizing
Bleaching

Singeing
Drying
Regulating atomizers, humidifiers, humidity controls, and sectional heads.
Melting gold, silver and alloys

Winding bobbins and coils

ITEMS REQUIRING MORE THAN ONE UNIT OF MEASUREMENT

Coffee pot - height (in.) capacity (pt.)
Creamer - " " " "
Water pitcher- " " " "
Syrup jar - " " " "
Beverage mixer -" " " "
Bronze Statuary- height(ft.) diameter (in.)
Cloth - length (yd.) width (in.)
Pipe - " (ft.) diameter (in.)
Fire hydrants - depth (ft.) diameter (in.)
Saddle stands- height(ft.) pipe size (in.)
Pipe pole supports- length(ft.) diameter (in.)
Indicator posts- length (ft.) diameter (in.)
Cast iron pipe- diameter(in.) pressure (lb.)
Elbows - diameter (in.) angle (degree)
Hose rack - capacity (ft.) valve size (in.)
Sight drip - diameter (in.) pressure (lb.)
Sight test connection-diameter(in.) pressure (lb.)
Check valves - diameter (in.) pressure (lb.)
Angle valves - " " " "
Gate valves - " " " "
Stop and check valves - diameter (in.) pressure (lb.)
Bronze cocks - " " " "
Iron " " " " "
Disc brass valves - " " " "
Valve discs - " " " "
Union bonnet valves - " " " "
Blow-off brass valves - " " " "
Meter boxes - " " weight "
Safety valves - " " pressure "
Reducing " " " " "
Flange fittings- diameter(in.) pressure(lb.) angle(degree)
Reducing laterals- " " " " " "
Bronze steam fittings- " " " " " "
Street elbows & tees " " " " " "
Couplings - " " " " " "
Screwed fittings- " " " " "
Metal pipe (threaded) " " length (ft.) weight (lb.)
Copper tubing - " " " " " "
Spigot pipe - " " " " " "
Gaskets - thickness(in.) weight per sq.yd. (lb.)
Foot valves- diameter(in.) valve area(sq.in.) weight (lb.)
A.P. safety valve- " " grate " (sq.ft.) pressure "
Water lifters- diameter (in.) Pressure (lb.)
capacity (gal.) (cu.ft.)
Machine parts and attachments - length (ft.) width and diameter (in.)
Nutaper coner - length (in.) taper (degree)
Speed of machine in winding - amount (yd.) per minute
Jeweler's findings - quantity (gross) weight (pennyweight)

It is apparent from this list that wherever two or more measurements are used in description they are independant of each other.

ANALYSIS OF NUMBER IN INDUSTRIES STUDIED

WHO NEED TO UNDERSTAND UNITS OF MEASUREMENT

	No.Employed	1st.Class	2ndClass	3rd.Class
Gorham Manufacturing Co.	770	83	64	623
U.S.Finishing Co.	437	37	29	371
Grinnell Co. Inc.	365	35	44	286
B.A.Ballou & Co. Inc.	132	21	13	98
Universal Winding Co.	957	111	175	671
Total	2661	287	325	2049
Percentage		11%	12%	77%

SUMMARY

TOTAL NUMBER OF ITEMS BY TABLES

Linear Measure	1484
Square Measure	59
Cubic Measure	77
Liquid Measure	45
Troy Weight	41
Avoirdupois Weight	190
Circular Measure	43
Unit Measure	100
Time	68
Paper Measure	4
Lumber Measure	4
Electric Measure	1
	2116
Number of Items requiring more than one unit of measurement	660
GRAND TOTAL	2776

TOTAL NUMBER OF ITEMS BY INDUSTRIES

Gorham Manufacturing Company	448
U. S. Finishing Company	72
Grinnell Company Inc.	735
B. A. Ballou & Company Inc.	167
Universal Winding Company	1344
GRAND TOTAL	2766

TOTAL NUMBER OF TABLES USED IN EACH INDUSTRY

Gorham Manufacturing Company	12
U. S. Finishing Company	7
Grinnell Company Inc.	9
B. A. Ballou & Company Inc.	9
Universal Winding Company	10

TOTAL NUMBER OF UNITS OF MEASUREMENT LISTED FOR STUDY		93
Less the units in tables not used		
Apothecaries' Fluid Measure	5	
" Weight	5	
Dry Measure	4	
Money Measure (U.S.)	6	
French Money	4	
English Money	4	28
Total number of units in 12 tables used in study		65
Less Units in these tables not involved in study		32
ACTUAL UNITS USED IN STUDY		33

CONCLUSIONS

In summarizing the data obtained in studying these five industries the following conclusions may be stated;

1. Of the 18 different tables of weights and measures listed, only 12 were required in the five industries studied.

2. Of the 93 possible units, the study has shown that only 33 units were used in these industries.

3. Over 3/4 of the persons employed in manufacturing in these industries did not need to use or understand any units of measurement. In other words, 11% are expert in fine measurement, 12% use the common tables of measurement and read simple blue-prints, while 77% are engaged in tasks which do not require the actual use of any measurement.

4. Therefore, only 23% of these persons employed are using the 33 units of the 93 units included in the 18 tables.

5. In using these units, the accuracy of the measurement is as important as the knowledge of the measurement itself.

6. A table of measurement, as such, is seldom used in its entirety. Only one unit of the table is necessary as a rule. Those who are working on small pieces using the inch, or parts of an inch, seldom have occasion to use the yard.

7. The units of measurement used in purchasing the raw materials differ from those used in manufacture. Generally speaking, larger units usually of volume and capa-

city are used with greater frequency in purchasing, while smaller units are used constantly in the processes of manufacture.

8. In the five industries studied, the inch was the most common unit of measurement, the pound (avoir.) ranking second in frequency.

9. A knowledge of standard tolerances allowed, in general, involves only the expert, usually the foreman and men employed in the engineering department. Others may be using a gauge which measures tolerance but they do not need to understand the actual measurements involved.

10. Any commodity is measured in a preferred unit, fixed by trade practice. This is equally true of a measurement used in the process of manufacturing. In other words, a person using a measurement uses it on a commodity and the fundamental point or basic fact is first, an understanding of that commodity. Handling the commodity with intelligence, therefore, comes first and knowledge of the unit of measurement follows.

11. Where the thousandth of an inch is the measurement constantly used, the thousandth of an inch is the unit. To be more specific, whatever degree of accuracy is commonly called for, that degree of accuracy becomes the unit of measurement in the operation involved.

Applications of Study

As a result of this study, the following suggestions might be made:

1. It is not profitable for children in the elementary grades to spend time on committing to memory tables of weights and measures.

2. When the pupil understands the commodity, it is not difficult for him to apply the preferred unit of measurement to that commodity.

3. The teaching of addition, subtraction, multiplication, and division of compound denominate numbers has little value.

4. Reduction ascending and reduction descending have no value in industry with perhaps the exception of the estimating department. It is,however, included in some text books but there is little justification for continuing it as a school exercise.

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